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Halophyte Distribution in Utah

Soils of high salinity pose two main problems to plants. First, the accumulation of sodium ions can lead to the poisoning of the plant. Second, high levels of NaCl cause the water potential of the soil to become very negative. When the water potential of the soil exceeds that inside of the plant, the ability to uptake water from the soil is lost and survival made improbable. Many areas throughout the state of Utah are covered by highly saline soils, particularly in the regions surrounding and immediately adjacent to the Great Salt Lake. The term "highly saline" is somewhat subjective "but 0.5% NaCl (equivalent to ~85mM) is accepted by most to be the lower threshhold of such a classification" (Glenn 7).

A halophyte is a plant that can tolerate above normal salinity. Many halophytes counteract the aforementioned problems by actually uptaking NaCl from the soil. The presence of extra ions within the plant creates a more negative internal water potential, allowing the plant to pull water from the salty soil. Halophytes have also become highly resistant to the toxic effects of sodium ions. Of the nearly 2,600 plants considered salt tolerant, Utah is home to a wide variety of halophytes. This paper will examine previous studies of halophytes in Utah and the factors that influence their distribution.

In the past century many studies of halophytes have been conducted in the areas surrounding the Great Salt Lake. The early studies often focused on the unique patterns of distribution among halophyte populations. In 1939, Herbert Gold observed that "each of the salt plants seem to have well-defined tolerance limits, the collective expression of which is apparent in a series of sharply drawn plant associations which concentrically band the lake" (Gold 2). This phenomenon had been observed much earlier and has now been thoroughly investigated.

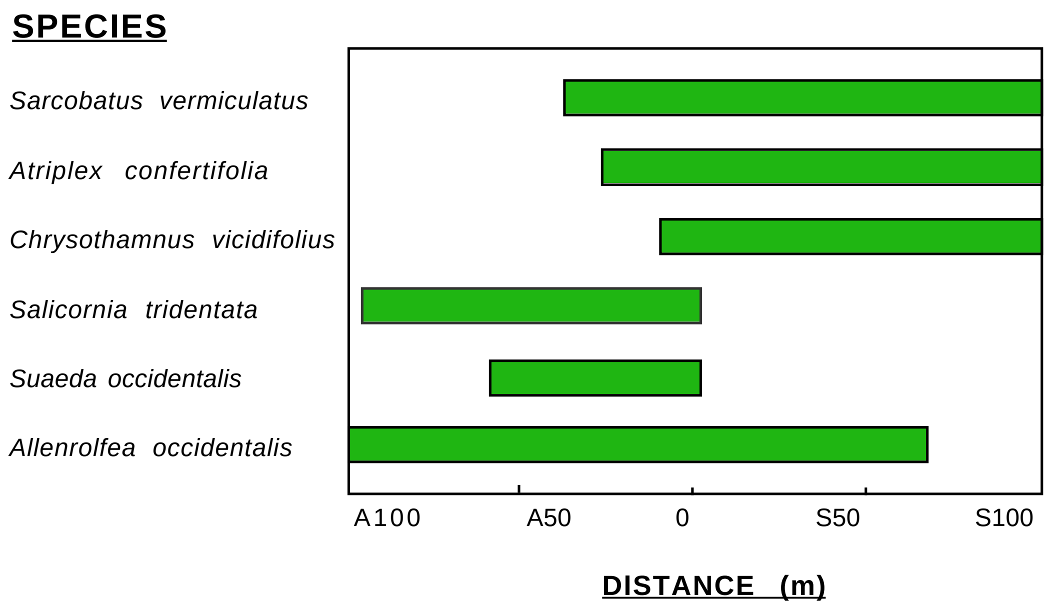
A common method for the study of such defined distribution patterns is to select a transect of land that passes through the growth zones of several plant types. Study sites are chosen along the transect and the desired experimental data gathered. When the soil salinity at is tested at successive sites, a salinity gradient is often encountered which usually correlates with the growth zones. For example, in 1995 Sandquist and Ehleringer selected a transect of land for investigation of carbon isotope discrimination among C4 halophytes. Although not the primary focus of the research, a salinity gradient was found to exist along the transect that corresponded with a change of dominant plant types.

In Goodman's 1973 study of the Curlew Valley in northern Utah, a clear relation was found between populations and soil salinity (as determined by conductivity experiments). In the area of highest salinity (121 mmho cm^{-1}) contained primarily *Allenrolfea occidentalis* (shown on the following page from USDA, NRCS1999) and *Salicornia* with a low population of *Atriplex nuttallii*. It was noted that the salinity levels of this area were high enough to cause precipitation of salt on the surface during the summer. As salinity dropped to 96 mmho cm^{-1} and 5.2 mmho cm^{-1}, the dominant species were *Atriplex nuttallii* and *Sarcobatus vermiculatus*. At the lowest levels of salinity the populations of various *Atriplex* species and *Eurotia* thrived.

The focus of the Goodman study was to investigate several exceptions to such defined distribution patterns. Like other researchers, Goodman noted a degree of overlap between populations along the salinity gradient. In some areas more than one species co-exist in mosaic communities while some species are found in various growth zones that differ greatly in salinity. In fact, Goodman observed that the subdominant species of the area, *Atriplex nuttallii,* occurred over an eighty-fold range of salinity in several zones of growth. Goodman was not alone in his findings. Many researchers have found that salinity limits distribution and that such overlap of species commonly occurs.

In a thesis published in 1984, Hesla thoroughly investigated a site in the Tooele Valley where monospecific communities of *Allenrofea occidentalis* and *Sarcobatus vermiculatus* meet. Again it was found that a salinity gradient existed at the site. In this case *Allenrofea* dominated the most saline areas while *Sarcobatus* eventually took over at lower salini[illegible] The division between populations along the salinity gradient was quite sharp, but like Goodman's study, a degree of overlap existed with several species. He also observed a drop in the water table that occurred at the interface between the populations. This was most likely due to a slight elevational change at the ecotone between the populations

The following graph shows the distributional limits of plant species within 100 meters of the ecotone between the populations of *Sarcobatus* and *Allenrolfea* (represented by the number 0). Horizontal distance is preceded by the first letter of the dominant species at that location.



(graph adapted from Hesla 12)

Hesla concluded that the salinity and texture of the soil, along with the water table depth dictated the distribution of these plants.

Salinity gradients also affect the growth response of individual halophytic plants. In his thesis, Hesla stated that for most halophytes, increasing salinities cause a decline in germination, establishment, growth, and reproduction (Hesla 18).As previously discussed, Goodman observed that *Atriplex nuttallii* occurred at many salinity levels. However, it is interesting to note that the growth response varied greatly as salinity levels changed. According to Goodman, the *Atriplex nuttallii* existed over an 80 fold salinity gradient and experienced a 20 fold decrease in biomass as salinity increased to a maximum. There were also several morphological differences such as decreasing leaf area and variations in stem size .

Although a high concentration of NaCl is not essential for optimal growth of halophytes, many benefit from it. Halophytes can be divided into two categories. Facultative halophytes do not require high levels of NaCl to survive, but can tolerate such conditions. Obligate halophytes are those that actually require higher levels of NaCl in order to exist. For example, *Salicornia Europaea* thrives at NaCl concentrations ranging from 170 mM to 340 mM but encounters difficulty in conditions void of salt. Table 1 shows the effect of salinity on growth parameters of *Salicornia Europaea*.

Table 1

NaCl (mM)	Dry mass (mg)	Height (cm)	Nodes	Lat. Branches
0.0	338	4	5	3
170.0	922	11	9	9
340.0	881	9	8	7
510.0	484	5	6	2

(Ungar 55)

This data clearly illustrates that *Salicornia* benefits from certain levels of NaCl in the soil. However, as salinity levels become more extreme the growth response of the individuals is greatly affected. It is interesting to note that even at the highest level of salinity the dry mass, height, and nodes of the plant are nearly comparable to the saline-free growth response.

In conclusion, the data from many studies clearly shows that the most important factor contributing to halophyte distribution patterns in Utah is soil salinity. It affects not only the type of plant that will dominate a site, but also has a great influence upon the growth of the individuals within a community.

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